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**APPLICATION NUMBER: 60/555,253**

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16562 U.S. PTO  
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## PROVISIONAL APPLICATION FOR PATENT COVER SHEET

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<input type="checkbox"/> Additional inventors are being named on the _____ separately numbered sheets attached hereto					
TITLE OF THE INVENTION (500 characters max)					
APPARATUS AND METHOD FOR SMOOTH PIXEL DIGITAL LIGHT PROCESSING					
Direct all correspondence to: CORRESPONDENCE ADDRESS					
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ENCLOSED APPLICATION PARTS (check all that apply)					
<input checked="" type="checkbox"/> Specification Number of Pages 6 <input type="checkbox"/> CD(s), Number _____					
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<input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76					
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT					
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.					
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Respectfully submitted,  
SIGNATURE   
TYPED or PRINTED NAME CHRISTINE JOHNSON  
TELEPHONE 1 609 734 6892

Date March 22, 2004

REGISTRATION NO 38507  
Docket Number: PU040040

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17858 U.S. PTO  
60/555253  
032204

<h1 style="margin: 0;">FEE TRANSMITTAL</h1> <h2 style="margin: 0;">for FY 2004</h2> <p style="font-size: small; margin: 5px 0;">Effective 10/01/2003. Patent fees are subject to annual revision.</p> <p><input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27</p>		<p><b>Complete if Known</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Application Number</td><td></td></tr> <tr><td>Filing Date</td><td></td></tr> <tr><td>First Named Inventor</td><td>MARK FRANCIS RUMREICH</td></tr> <tr><td>Examiner Name</td><td></td></tr> <tr><td>Art Unit</td><td></td></tr> <tr><td>Attorney Docket No.</td><td>PU040040</td></tr> </table>		Application Number		Filing Date		First Named Inventor	MARK FRANCIS RUMREICH	Examiner Name		Art Unit		Attorney Docket No.	PU040040
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<b>TOTAL AMOUNT OF PAYMENT</b> (\$) 160															

<p><b>METHOD OF PAYMENT</b> (check all that apply)</p> <p><input type="checkbox"/> Check   <input type="checkbox"/> Credit card   <input type="checkbox"/> Money   <input type="checkbox"/> Other   <input type="checkbox"/> None Order</p> <p><input checked="" type="checkbox"/> Deposit Account:</p> <p>Deposit Account Number: 07-0832</p> <p>Deposit Account Name: THOMSON LICENSING INC.</p> <p>The Director is authorized to: (check all that apply)</p> <p><input checked="" type="checkbox"/> Charge fee(s) indicated below   <input type="checkbox"/> Credit any overpayments</p> <p><input checked="" type="checkbox"/> Charge any additional fee(s) during the pendency of this application</p> <p><input type="checkbox"/> Charge fee(s) indicated below, except for the filing fee to the above-identified deposit account.</p>	<p><b>FEE CALCULATION</b> (continued)</p> <p><b>3. ADDITIONAL FEES</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2">Large Entity</th> <th colspan="2">Small Entity</th> <th rowspan="2">Fee Description</th> <th rowspan="2">Fee Paid</th> </tr> <tr> <th>Fee Code</th> <th>Fee (\$)</th> <th>Fee Code</th> <th>Fee (\$)</th> </tr> </thead> <tbody> <tr><td>1051</td><td>130</td><td>2051</td><td>65</td><td>Surcharge - late filing fee or oath</td><td></td></tr> <tr><td>1052</td><td>50</td><td>2052</td><td>25</td><td>Surcharge - late provisional filing fee or cover sheet.</td><td></td></tr> <tr><td>1053</td><td>130</td><td>1053</td><td>130</td><td>Non-English specification</td><td></td></tr> <tr><td>1812</td><td>2,520</td><td>1812</td><td>2,520</td><td>For filing a request for reexamination</td><td></td></tr> <tr><td>1804</td><td>920*</td><td>1804</td><td>920*</td><td>Requesting publication of SIR prior to Examiner action</td><td></td></tr> <tr><td>1805</td><td>1,840*</td><td>1805</td><td>1,840*</td><td>Requesting publication of SIR after Examiner action</td><td></td></tr> <tr><td>1251</td><td>110</td><td>2251</td><td>55</td><td>Extension for reply within first month</td><td></td></tr> <tr><td>1252</td><td>420</td><td>2252</td><td>210</td><td>Extension for reply within second month</td><td></td></tr> <tr><td>1253</td><td>950</td><td>2253</td><td>475</td><td>Extension for reply within third month</td><td></td></tr> <tr><td>1254</td><td>1,480</td><td>2254</td><td>740</td><td>Extension for reply within fourth month</td><td></td></tr> <tr><td>1255</td><td>2,010</td><td>2255</td><td>1,005</td><td>Extension for reply within fifth month</td><td></td></tr> <tr><td>1401</td><td>330</td><td>2401</td><td>165</td><td>Notice of Appeal</td><td></td></tr> <tr><td>1402</td><td>330</td><td>2402</td><td>165</td><td>Filing a brief in support of an appeal</td><td></td></tr> <tr><td>1403</td><td>290</td><td>2403</td><td>145</td><td>Request for oral hearing</td><td></td></tr> <tr><td>1451</td><td>1,510</td><td>1451</td><td>1,510</td><td>Petition to institute a public use proceeding</td><td></td></tr> <tr><td>1452</td><td>110</td><td>2452</td><td>55</td><td>Petition to revive - unavoidable</td><td></td></tr> <tr><td>1453</td><td>1,330</td><td>2453</td><td>665</td><td>Petition to revive - unintentional</td><td></td></tr> <tr><td>1501</td><td>1,330</td><td>2501</td><td>665</td><td>Utility issue fee (or reissue)</td><td></td></tr> <tr><td>1502</td><td>480</td><td>2502</td><td>240</td><td>Design issue fee</td><td></td></tr> <tr><td>1503</td><td>640</td><td>2503</td><td>320</td><td>Plant issue fee</td><td></td></tr> <tr><td>1460</td><td>130</td><td>1460</td><td>130</td><td>Petitions to the Commissioner</td><td></td></tr> <tr><td>1807</td><td>50</td><td>1807</td><td>50</td><td>Processing fee under 37 CFR 1.17 (q)</td><td></td></tr> <tr><td>1806</td><td>180</td><td>1806</td><td>180</td><td>Submission of Information Disclosure Stmt</td><td></td></tr> <tr><td>8021</td><td>40</td><td>8021</td><td>40</td><td>Recording each patent assignment per property (times number of properties)</td><td></td></tr> <tr><td>1809</td><td>770</td><td>2809</td><td>385</td><td>Filing a submission after final rejection (37 CFR § 1.129(a))</td><td></td></tr> <tr><td>1810</td><td>770</td><td>2810</td><td>385</td><td>For each additional invention to be examined (37 CFR § 1.129(b))</td><td></td></tr> <tr><td>1801</td><td>770</td><td>2801</td><td>385</td><td>Request for Continued Examination (RCE)</td><td></td></tr> <tr><td>1802</td><td>900</td><td>1802</td><td>900</td><td>Request for expedited examination of a design application</td><td></td></tr> </tbody> </table> <p>Other fee (specify) _____</p> <p>*Reduced by Basic Filing Fee Paid      <b>SUBTOTAL (3)</b> (\$) 0</p>	Large Entity		Small Entity		Fee Description	Fee Paid	Fee Code	Fee (\$)	Fee Code	Fee (\$)	1051	130	2051	65	Surcharge - late filing fee or oath		1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet.		1053	130	1053	130	Non-English specification		1812	2,520	1812	2,520	For filing a request for reexamination		1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action		1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action		1251	110	2251	55	Extension for reply within first month		1252	420	2252	210	Extension for reply within second month		1253	950	2253	475	Extension for reply within third month		1254	1,480	2254	740	Extension for reply within fourth month		1255	2,010	2255	1,005	Extension for reply within fifth month		1401	330	2401	165	Notice of Appeal		1402	330	2402	165	Filing a brief in support of an appeal		1403	290	2403	145	Request for oral hearing		1451	1,510	1451	1,510	Petition to institute a public use proceeding		1452	110	2452	55	Petition to revive - unavoidable		1453	1,330	2453	665	Petition to revive - unintentional		1501	1,330	2501	665	Utility issue fee (or reissue)		1502	480	2502	240	Design issue fee		1503	640	2503	320	Plant issue fee		1460	130	1460	130	Petitions to the Commissioner		1807	50	1807	50	Processing fee under 37 CFR 1.17 (q)		1806	180	1806	180	Submission of Information Disclosure Stmt		8021	40	8021	40	Recording each patent assignment per property (times number of properties)		1809	770	2809	385	Filing a submission after final rejection (37 CFR § 1.129(a))		1810	770	2810	385	For each additional invention to be examined (37 CFR § 1.129(b))		1801	770	2801	385	Request for Continued Examination (RCE)		1802	900	1802	900	Request for expedited examination of a design application	
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<b>SUBMITTED BY</b>		<b>Complete (if applicable)</b>	
Name (Print/Type)	CHRISTINE JOHNSON	Registration No. (Attorney/Agent)	38507
Signature		Telephone	1 609 734 6892
		Date	3/22/04 March 22, 2004

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## APPARATUS AND METHOD FOR SMOOTH PIXEL DIGITAL LIGHT PROCESSING

### **Field of the Invention**

[0001] The present invention generally relates to a filter to pre-correct video prior to "smooth pixel DLP" processing.

### **Background of the Invention**

[0002] Smooth pixel Digital Light Processing (DLP) "contaminates" each pixel with the upper, lower, left & right adjacent input pixels, thereby blurring the image in some cases. Pre-correction filters for other applications are traditionally either the cascade of vertical and horizontal filters, or involve diagonal coefficients. These filters involve "noncontaminating pixels" and therefore, in some cases, do not adequately correct the problem. One proposed approach to Digital Light Processing (DLP) is referred to as "Smooth pixel DLP". In this approach, rather than using traditional square pixels oriented horizontally and vertically, square pixels are rotated 45 degrees. The rotated pixels are referred to as "diamond pixels" (see figure 1).

[0003] According to a proposed technique, in addition to using diamond pixels, smooth pixel DLP modulates the angle of a mirror in the image light path in order to increase the effective resolution. By changing the angle of the mirror, the diamond pixels are shifted downward by half a pixel, resulting in a secondary set of pixels centered on the interstices of the primary set of pixels (see figure 2).

[0004] The modulation produces both primary and secondary pixel sets for each incoming picture, effectively doubling the number of pixels. But because of the overlap between pixel sets, there is a loss of apparent resolution (as compared to having the combined number of pixels in a non-overlapping arrangement). In other words, each combined pixel is "contaminated" by the four adjacent pixels of the other pixel set. Accordingly, devices and methods for canceling the contamination effect are needed.

**Summary of the Invention**

[0005] The present invention is an apparatus and method for pre-correcting video to reduce the contamination effect caused by smooth pixel DLP modulation.

**Brief Description of the Drawings**

Preferred embodiments of the present invention will be described below in more detail, with reference to the accompanying drawings, in which:

Figure 1 is an illustration of a "diamond pixel" of the prior art.

Figure 2A is an illustration of a primary pixel set.

Figure 2B is an illustration of a secondary pixel set.

Figure 2C is an illustration of a combined pixel set.

Figure 3A is an illustration of a primary pixel set.

Figure 3B is an illustration of a primary pixel set.

Figure 3C is an illustration of a combined pixel set.

Figure 4 is a diagram of a filter according to an embodiment of the invention.

**Detailed Description**

[0006] "Smooth pixel DLP" is a term used to refer to Texas Instruments approach to a form of Digital Light Processing. Instead of using traditional square pixels oriented horizontally and vertically, square pixels are rotated 45 degrees. These are referred to as "diamond pixels" (see figure 1).

[0007] In addition to using diamond pixels, one approach to smooth pixel DLP modulates the angle of a mirror in the image light path in order to increase the effective resolution. By changing the angle of the mirror, the diamond pixels are shifted downward by half a pixel, resulting in a secondary set of pixels centered on the interstices of the primary set of pixels (see figure 2).

[0008] The modulation produces both primary (Figure 2A) and secondary (Figure 2B) pixel sets for each incoming picture. This effectively doubles the number of pixels. But because of the overlap between pixel sets, there is a loss of apparent resolution (as

compared to having the combined number of pixels in a non-overlapping arrangement) (Figure 3B). In other words, each combined pixel (Figure B) is contaminated by the four adjacent pixels of the other pixel set. The invention is a system and method of substantially canceling this effect.

[0009] According to an embodiment of the invention, each incoming pixel data point directly corresponds to one pixel on the combined pixel grid. For example, in an illustrative embodiment of the invention, the incoming pixel data for one component (in one embodiment YUV, in an alternative embodiment RGB) is as follows:

A	B	C	D	E
F	G	H	I	J
K	L	M	N	O

[0010] Figures 3A, 3B and 3C show how the above input samples are mapped to the smooth pixels. Referring to figure 3, each input pixel is "contaminated" by the four adjacent pixels of the other pixel set. For example, the H pixel is contaminated by the C, G, I and M pixels. In other words, each pixel is contaminated by the upper, lower, left and right adjacent pixels in the incoming pixel data. By using a pre-correction filter of the present invention on the incoming pixel data, it's possible to offset the degradation due to this contamination effect.

[0011] In one embodiment of the invention, a two-dimensional precorrection filter configured as follows is employed:

$$\begin{array}{ccc} & \alpha & \\ \alpha & \beta & \alpha \\ & \alpha & \end{array}$$

[0012] In one embodiment of the invention, alpha is  $-1/8$ . This provides provide unity DC gain and optimum pre-correction. In an embodiment of the invention, Beta is  $1 - 4*\alpha$  for unity DC gain. In one embodiment of the invention, for  $\alpha = -1/8$ , beta is  $3/2$ . In effect, the filter of an embodiment of the invention subtracts out contaminating

pixel information from each input pixel. By processing the input pixel data with this filter, pre-corrected input pixel data is provided. The pre-corrected pixel data is then processed by smooth pixel processing.

A	B	C	D	E		A'	B'	C'	D'	E'
F	G	H	I	J	→	F'	G'	H'	I'	J'
K	L	M	N	O		K'	L'	M'	N'	O'

[0013] Figure 4 illustrates a filter in accordance with an embodiment of the invention. In this embodiment, eight levels of pre-correction are provided, from  $\alpha = 0$  to  $\alpha = -7/32$ , in  $1/32$  steps.

[0014] While foregoing is directed to the preferred embodiment of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.



**Claims**

1. A method for filtering pixel data comprising the steps of:  
applying a pre-correction filter to said pixel data to provide pre-corrected pixel  
5 data;  
smooth pixel processing said pre-corrected pixel data.

**Abstract of the Disclosure**

A method and apparatus are disclosed for filtering pixel data. The method comprises the steps of applying a pre-correction filter to the pixel data to provide pre-corrected pixel data. The pre-corrected pixel data is subjected to smooth pixel processing.

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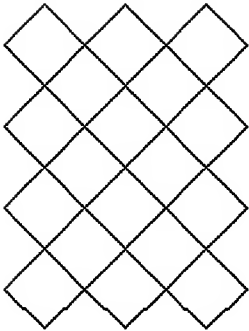


Figure 1

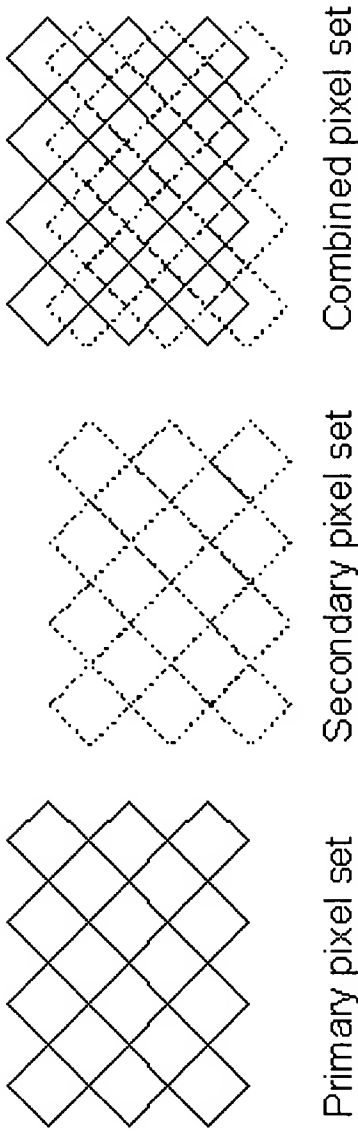


Figure 2A      Figure 2B      Figure 2C

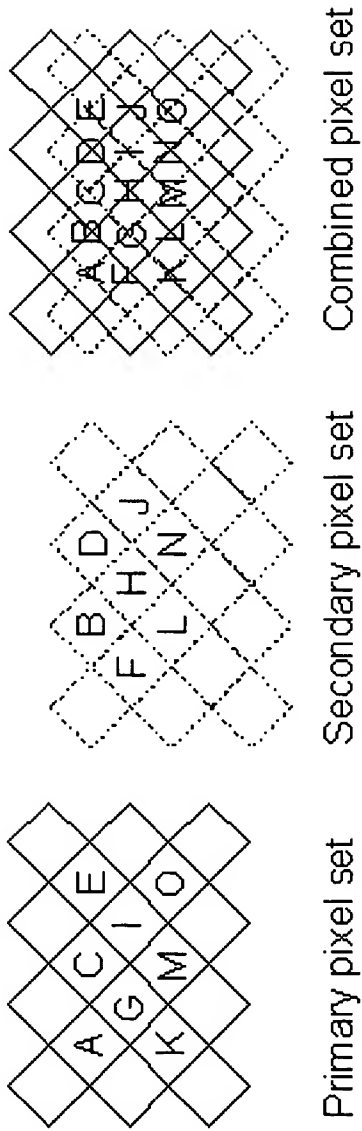


Figure 3A      Figure 3B      Figure 3C

